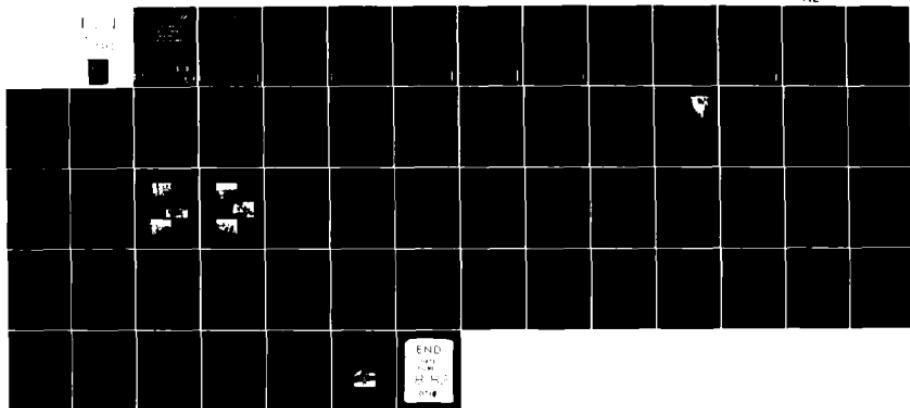
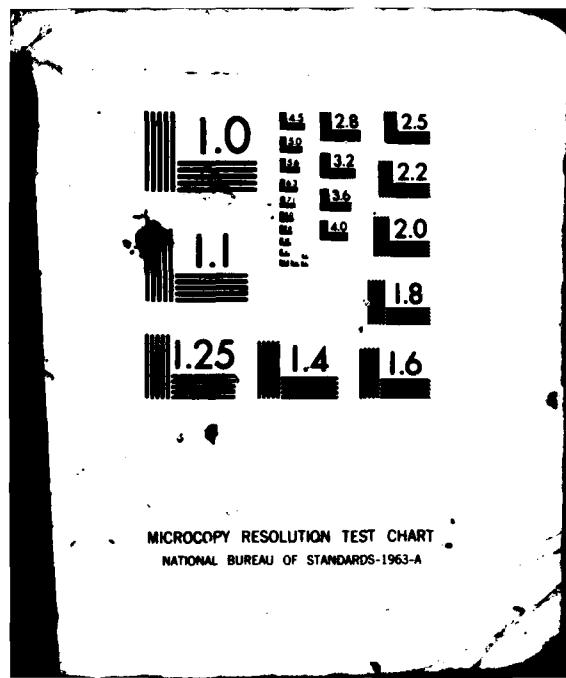


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**PHYSICAL PERFORMANCE TASKS  
REQUIRED OF U.S. MARINES  
OPERATING IN A HIGH ALTITUDE  
COLD WEATHER ENVIRONMENT**

AD A117462

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**PAUL O. DAVIS  
ARTHUR V. CURTIS  
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Through the use of minicassette recorders, scales, cameras and other data collection equipment, scenarios were described which typify the critical, frequent and strenuous types of tasks indigenous to marines in this environment.

Distances covered on foot, loads carried, rates of travel and grades encountered were detailed and described, as well as other environmental overlays which impact on troop performance. Sustained marches, under varied atmospheric conditions, weighted with awkward personal protective equipment approaching 70% of one's body weight, was identified as the overriding physical task in this environment. Unpacked snow, and grades of 10-15° were routinely encountered. An ability to maintain a line of march for periods of four to six hours were not uncommon. The arduous nature of this task was confounded by frequent falling into deep snow while wearing snow shoes and having to reestablish an upright position. ↗

Upper body and leg strength requirements included an ability to lift up to 80 pounds (the weight of pack and ammunition) to shoulder height from the ground. The pulling of a loaded sled (375-500 pounds) using a rope and harness with a team of other marines (usually 3, for a total of 4 marines), up inclines of 15° would be classified as a high strength requirement.

It was determined that operations conducted in this environment would be classified as arduous and highly physical in nature, particularly when compared to operations observed previously in a desert environment.

A taxonomy of physical tasks from this environment were added to physical performance data from other Marine theaters of operations for the purpose of developing a complete job analysis of activities involving strength and endurance factors.

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**PHYSICAL PERFORMANCE TASKS  
REQUIRED OF UNITED STATES MARINES  
OPERATING IN A HIGH ALTITUDE  
COLD WEATHER ENVIRONMENT**

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July, 1982

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ABSTRACT

Ten representatives of the Institute of Human Performance were integrated into a marine battalion during a high altitude cold weather training operation for the purpose of gathering descriptive and objective information about the types of physical performance tasks encountered by marine infantrymen (MOS 0311).

Through the use of minicassette recorders, scales, cameras and other data collection equipment, scenarios were described which typify the critical, frequent and strenuous types of tasks indigenous to marines in this environment.

Distances covered on foot, loads carried, rates of travel and grades encountered were detailed and described, as well as other environmental overlays which impact on troop performance. Sustained marches, under varied atmospheric conditions, weighted with awkward personal protective equipment approaching 70% of one's body weight, was identified as the overriding physical task in this environment. Unpacked snow, and grades of 10-15° were routinely encountered. An ability to maintain a line of march for periods of four to six hours were not uncommon. The arduous nature of this task was confounded by frequent falling into deep snow while wearing snow shoes and having to reestablish an upright position.

Upper body and leg strength requirements included an ability to lift up to 80 pounds (the weight of pack and ammunition) to shoulder height from the ground. The pulling of a loaded sled (375-500 pounds) using a rope and harness with a team of other marines (usually 3, for a total of 4 marines), up inclines of 15° would be classified as a high strength requirement.

It was determined that operations conducted in this environment would be classified as arduous and highly physical in nature, particularly when compared to operations observed previously in a desert environment.

A taxonomy of physical tasks from this environment will be added to physical performance data from other Marine Corps theaters of operations for the purpose of developing a complete job analysis of activities involving strength and endurance factors.

## **SECTION 1.0: INTRODUCTION**

### **1.1 Study Purpose**

The purpose of this work was to gather descriptive and objective information regarding the physical performance tasks required of United States Marines with the MOS 0311 (rifleman) in a high altitude/cold weather theater of operation. This information, along with data collected from a similar analysis conducted previously in a desert environment, will serve as the basis for developing a job-related physical performance examination capable of predicting the combat readiness of marines faced with the prospects of action in various operational environments.

### **1.2 Background**

Headquarters, USMC (Code TRI) has the responsibility for the administration of the current Physical Fitness Test (PFT). This test has existed for nine years and represents a fitness battery consisting of items whose capability of predicting combat readiness has not been scientifically validated. The test battery consists of pull-ups, sit-ups and a three-mile run (1).

Scoring of the PFT is arbitrary, and does not take into account such factors as environment (i.e. temperature and terrain), loads carried or numerous other factors that will no doubt have a profound impact on combat capabilities and readiness. Once again, the relationship between combat performance and scores on the PFT has neither been investigated nor established on the basis of any empirical work.

Noting these shortcomings, representatives of HQMC approached the Institute of Human Performance regarding the possibility of improving the validity of the PFT, as well as augmenting the PFT with other measures that would allow battalion commanders to validly assess the combat readiness of

their troops. In view of the Navy's responsibility for supporting efforts of this type, an unsolicited proposal was submitted to the Naval Medical Research and Development Command that specified a multiphasic approach for accomplishing this objective, with each phase concentrating on physical tasks performed in a distinct combat environment.

As part of the first phase of this effort, a review of the literature was conducted to ascertain existing analyses and job descriptions of the rifleman and/or infantryman (MOS 0311). At that time (1979), only broad, poorly defined statements of the physical tasks performed by this MOS were available. There is now a published document entitled Individual Training Standards (ITS) which contains a more complete listing of tasks performed by this MOS. However, the emphasis of this document is on cognitive tasks, with little information available on physical tasks or the environmental conditions under which these tasks are to be performed. A well-planned and carefully constructed job analysis of physical tasks was still required, preferably conducted under the various environmental conditions in which the rifleman would be operating.

### 1.3 Related Studies

Many military occupations do not involve combat or require physical performance, and are therefore not useful in providing information on the development of physical performance standards for the Marine Corps. Developing such standards for the Marine Corps using the rifleman MOS as the basis of this development does have an advantage in that the Corps believes that every marine is fundamentally a rifleman, and as such, only a single minimum set of standards needs to be developed for the entire Corps. Since the Marine Corps' mission involves combat under a number of different environmental conditions, gathering information on physical

performance in a variety of combat environments (desert, cold, tropical and amphibious) must be an integral part of the data collection process.

Testing for physical fitness and combat readiness probably had its origins in ancient Greece. The first empirical analysis of modern military tasks appears to have been conducted by Brezina and Kolmer in 1912 (2). In a classic 1923 job analysis of the Royal Army undertaken by Cathcart, Richardson and Campbell, it was noted that "the heavier loads were a distinct menace to the maintenance of normal cardiac activity" (3).

A review of current military and civilian job-analysis methods has revealed that a number of options exist that would comply with the Uniform Guidelines on Employee Selection Procedures.<sup>(4)</sup> These guidelines represent the consensus of those federal agencies (Departments of Labor, Office of Personnel Management, Equal Employment Opportunity Commission, Department of Justice and Department of the Treasury) regarding the methods and procedures for the validation and development of pre-employment tests. The procedures outlined in the Guidelines detail several recognized approaches to the development of job-related performance tests.

The Army, through the Research Institute of Environmental Medicine (USARIEM), has conducted an extensive survey of physical tasks performed by a variety of Army MOS's.<sup>(5)</sup> On the basis of these findings, MOS's have been sorted into five clusters. However, the major purpose of this work was to develop a screening device to be used at the AFEES centers, and not as a tool to predict combat readiness.

USARIEM has also conducted an analysis of energy expenditure of soldiers involved in combat operations in a tropical environment<sup>(6)</sup>. This work found the upper limits of energy expenditure to be in the range of 400 to 450 kcal per hour. Total weight or load carried by infantrymen represented the most critical factor in this energy requirement. Terrain

was independently related to energy requirements, but to a lesser degree than load.

Job-analyses currently being conducted by the Navy<sup>(7)</sup> and the Air Force<sup>(8)</sup> have little applicability to Marine Corps tasks because little similarity exists in the jobs currently under study (i.e. few Navy and Air Force tasks have physical evidence requirements typical of marine tasks). This work does, however, use onsite observation and measurement to assess physical performance, similar to the approach proposed for the Marine Corps.

It is interesting to note the trend towards on-the-job measurement, as opposed to pencil and paper job analysis. With the increased capability associated with portable metabolic measurement equipment and other micro-electronic measurement equipment, the more subjective (i.e., paper and pencil) methods of data collection are rapidly being discarded. In addition, observation and measurement by trained exercise physiologists represent the optimum method of gathering data needed to construct a taxonomy of physical performance tasks. Individual interview and observation have been demonstrated as the most reliable methods of gathering information regarding the specific dimensions of physical performance.<sup>(9)</sup> Clearly, obtaining reliable and valid data on the physical tasks of marines through some method other than onsite observation represents a less than preferred approach. To perform the work described below, a team of ten trained observers was used. These observers had an academic background in exercise physiology, work physiology, zoology, physical education, or allied health sciences, with extensive experience in assessing physical performance. Four members of the team had doctoral degrees, while the remaining five members had bachelor's and master's degrees.

## **SECTION 2.0: METHODOLOGY**

Section 2.0 describes the approach used to accomplish the purpose of this project (i.e., laboratory assessment and observation of Marines performing combat tasks in a high altitude, cold weather environment). Figure 2.1 presents the sequence of project tasks and the order in which these tasks were accomplished.

### **2.1 Site Selection**

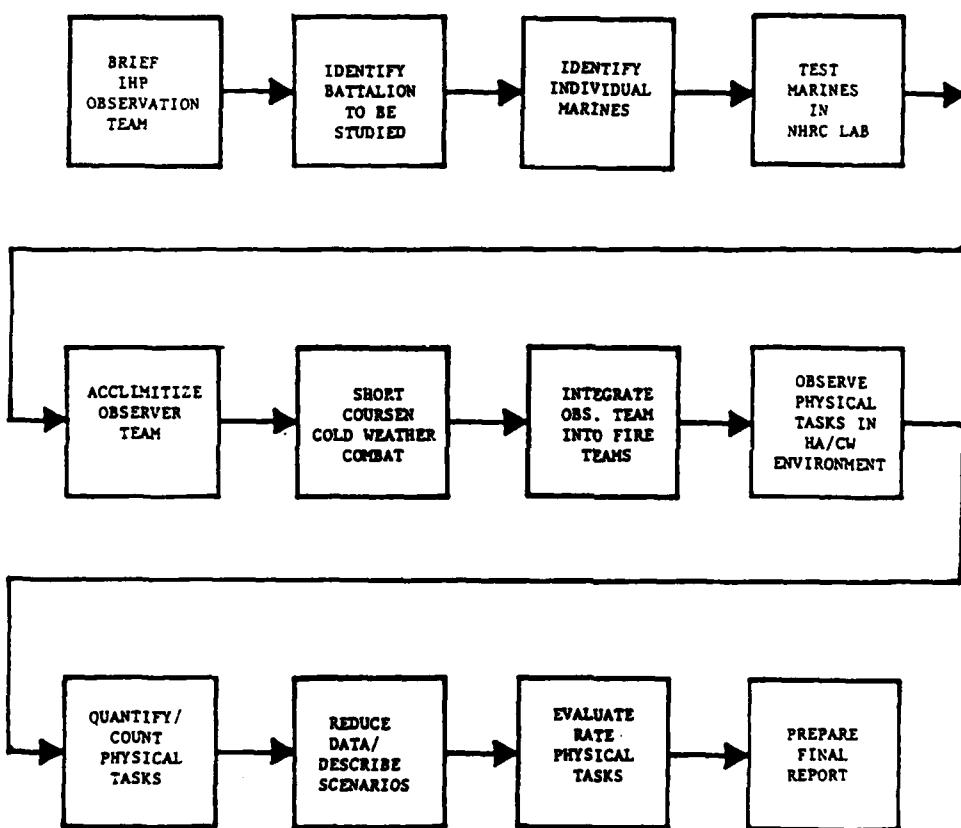
A series of meetings were held between staff members of IHP and representatives of Headquarters Marine Corps (Code TRI). As a result of these meetings, it was determined that observations and data collection would be conducted at the Mountain Warfare Training Center (MWTC) located at Pickel Meadows, California.

The MWTC is located in the Sierra Mountains, in the Toiyabe National Forest, of Northern California. The base camp is 6,700 feet above sea level. It is an excellent location for high-altitude, cold weather (HA/CW) infantry training. Field exercises are conducted at altitudes of 7,000 to 10,000 feet, with temperatures ranging from -20°F to 50°F. Snow accumulation ranges between 3 and 15 feet. The MWTC has a variable terrain, including expanses of open glade, bounded by sheer cliffs.

### **2.2 Battalion Selection**

Through the coordination of Unit Training, Cold Weather Operations, Headquarters Marines, (code TRU), it was determined that the 3rd Battalion, 5th Marines (designated 3/5) would be training at Pickel Meadows during the period identified as optimal for observing winter combat operations (i.e. February-March).

**FIGURE 2.1**



### **2.3 Liaison with 3rd Battalion, 5th Marines**

A preliminary meeting was held with the Battalion CO and his staff at Camp Pendleton, California to discuss the purpose of the project and to coordinate the IHP effort with the battalion training schedule. The commissioned and non-commissioned officers of the battalion were also briefed as to the purpose of the project. The officers of the battalion were asked to select 24 marines as subjects to be observed by the IHP team for job-analysis. It was specified that the subjects should be working in the military occupational specialty MOS 0311. Each rifle platoon in the battalion was requested to provide subjects, preferably no more than one subject from a single squad. This provided a pool of 24 subjects from whom 20 would be randomly selected by the IHP staff for observation. This request was made to provide the observation team with exposure to the wide variety of combat tasks that would occur during the simulated combat problem because rifle platoons have different functions such as stay platoons, recon units, and aggressors. The standard to be used in making these selections was that the marines should be those who they would prefer to have in their command in an actual combat situation.

Following selection, the subjects were administered the Marine Corps's physical fitness test (PFT) by their NCO's and the results of these tests were provided to IHP. A more definitive evaluation of the subjects would be conducted later at NHRC (Naval Health Research Center) in San Diego (see below).

### **2.4 Naval Health Research Center (NHRC) Participation**

Following subject selection and the establishment of the EA/CW observation dates, IHP contacted NHRC to determine the availability of physical fitness assessment facilities. The experimental approach called

for assessing the physiological capabilities of the marines who were to be observed during the cold weather operations. NERC agreed to conduct this physiological evaluation, and also provided IHP with the services of a staff physiologist to serve as a member of the observation team.

### **2.5 Observation Team Training**

Several meetings were conducted with the members of the observation team to familiarize them with the cold weather environment conditions likely to be encountered during the operation, and to review standardized methods of data collection. Dr. Murray Hamlet from the U.S. Army Research Institute of Environmental Medicine (USARIEM) was invited to the IHP corporate headquarters to present research findings dealing with cold weather morbidity and cold weather acclimatization. Data collection techniques to be used during the operation were then reviewed and discussed. These included measurement of loads carried, terrain characteristics, distances covered, and other relevant environment factors. Speeds for movement by foot were to be tape recorded and classified as:

Slow Walk	(1 - 2.0 mph)
Fast Walk	(2.1 - 3.4 mph)
Slow Run	(3.5 - 4.4 mph)
Fast Run	(4.5 mph or greater)

Grades were to be recorded in degrees of inclination. Previously, estimates of grade had been made through the subjective interpretation of the observer. For the HA/CW project, inclinometers were used by each member of the team in order to obtain an objective assessment of terrain grade.

The specific sequence used in recording data is provided in Table 2.1.

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**TABLE 2.1**  
**DATA ENTRY SYSTEM FOR TAPE RECORDERS**

---

**BEGIN TAPE:**

1. Observer
2. Date
3. Time
4. Tape #

**RECORD:**

1. Distances
2. Speeds
3. Grade
4. Body Position
5. External Loads
6. Footing
7. Obstacles

---

As was the case in previous field data collection efforts, (Physical Performance Tasks Required of U.S. Marines Operating in Desert Environment)<sup>(10)</sup>, the observers would wear the utility and combat uniform of the marines and would integrate with the battalion as fire team members. This was done to minimize interference with the normal flow of the combat problem. Tables 3.9-3.12 contain a complete listing of clothing issued by the IHP team during cold weather operations. Figure 3.6 provides an example of this clothing being worn by marines and members of the IHP observation team.

## **2.6 Data Collection/Recording Equipment**

Data collection/recording equipment previously purchased for similar work in the desert environment had been retained and was issued again for this work. Each team member was issued a tape recorder (Norelco 185 minicassette) for recording descriptive information, a camera (Olympus XA) to visually document the task, and a 25-Kg scale (Chatillon IN-50) divided into 250-gram measurements to weigh articles carried by subjects. The inclinometer, mentioned above, was also issued.

## **2.7 Physiological Assessment at NHRC**

Prior to embarkation to the MWTC, the 24 subjects were transported by Marine Corps trucks to NHRC for physiological assessment by the NERC and IHP staffs. Physical fitness evaluation of the subjects was conducted over a two-day period. During this period the subjects were housed at the Marine Corps' Recruit Depot and shuttled by van to NHRC as required. On arrival, each subject was briefed by an IHP investigator about the evaluation techniques to be used.

### **2.7.1 Determination of Percent Body Fat**

Initially, the height and weight of each subject was measured. Skinfold measurements were then taken using a Harpenden skinfold caliper. Skinfold sites included the subscapula, triceps, biceps, pectoralis, and suprailiac. Neck and abdominal circumferences were obtained using a Gulick tape measure. Percent fat was estimated using the formula of Wright, Dotson and Davis (11).

### **2.7.2 Resting Blood Pressure and EKG**

Resting blood pressure was measured in the supine position. A resting, 12-lead EKG was also obtained. Resting heart rate was measured directly from the resting EKG.

### **2.7.3 Aerobic Fitness Assessment**

Maximum O<sub>2</sub> uptake was measured using a treadmill protocol developed by Dr. James Hodgedon of NERC. All tests were performed using a Quinton Model 18-60 treadmill. The subjects were instructed to exert themselves maximally. Expiratory gas analysis was performed and results were computed on-line using a Hewlett Packard Computing system (see figure 2.3). This technique allowed for constant monitoring of the Respiratory Exchange Ratio and a determination of the level of effort expended. Blood pressure was monitored during the exercise test. Heart rate and EKG were continuously monitored during the entire procedure.

### **2.8 Observation at Pickel Meadows**

The training schedule at the MWTC allowed the marines to acclimatize over a period of three weeks to the HA/CW environment while learning mountain warfare tactics and survival. The final three days of the schedule had been reserved for a simulated combat exercise that would provide the marines with an opportunity to apply this knowledge. The IHP observation team was briefed by battalion officers on plans for this three-day combat exercise.

One reinforced rifle squad had been designated the aggressor unit, and wore a black arm band on the outer camouflage garment. This aggressor unit, referred to as "Super Squad", was composed of the most outstanding marines from the battalion. They represented the battalion in the annual Marine Corps-wide squad competition.

The individual units were clothed in snow camouflage (i.e., white cover) and loaded into trucks for transport to the vicinity of the exercise area. The final 3-4 miles of travel to the exercise area was accomplished on snow shoes, skis or foot.

On reaching the exercise area, each member of the observation team was paired with the first of the two subjects he was assigned to observe. Measurement and descriptive information were then collected by the observer, including weighing the equipment worn and carried by each subject. The platoon commanders were informed that the observation team members were to be considered as part of the fire team. At this point, each observer was, for all intents and purposes, geographically isolated from the rest of the observation team.

As the subjects engaged in the exercise activities, the observers followed, maintaining close visual contact. Variations in movement, loads and terrain for each subject were noted by the assigned observer using the minicassette recorder and camera. After one and a half days, each observer was paired with the second subject to which he was assigned. The same data were collected for this subject as for the first subject until the end of the exercise, one and a half days later.

At the conclusion of the exercises, the marines and IHP observers marched to the base camp at Pickel Meadows where the members of the observation team were debriefed by the battalion staff.

#### **2.9 Preparation of Observer Reports**

During the two weeks following the exercise at Pickel Meadows, each observer reviewed his notes and was provided with copies of photographs in order to refresh his memory. Several staff meetings were held with the observers to discuss and identify physical tasks commonly performed by the marine subjects. This information was consolidated by each observer into a written report according to the procedures outlined by Hogan and Bernacki<sup>(12)</sup>. Section 3.0 describes the results of this work.

## **SECTION 3.0: RESULTS**

### **3.1 Laboratory Evaluation Results**

Physical description, body composition and anthropometric data are displayed on Table 3.1. Body composition data show that this marine group was slightly less fat than data reported for marine subjects in the group studied previously (i.e. during desert operations). While the ages of the two groups were nearly identical (20.7 vs. 20.8 years), the group observed during this exercise were smaller in stature (4.7 cm), lighter in total weight (3.74 kg), had less total fat weight (1.33 kg) and less lean body mass (5.94 kg).

Dynamic measures of aerobic fitness are presented in Table 3.2. Maximum aerobic capacity would be considered high/normal for this sample compared to age-matched controls. The marines from 3/5 were judged slightly more fit than the marines from 2/2 (the battalion observed during desert operations), as determined by oxygen uptake values expressed as a function of body weight (54.09 vs. 52.41).

Aerobic threshold was determined to be greater for this subject group as compared to the previously studied group (37.9 vs. 33.0), while maximum attained heart rate was lower (194 vs. 179 bpm). The scores for the two groups of marines are compared in Table 3.3. Significant differences are noted, using a confidence level of .05 or greater.

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**TABLE 3.1**

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**SUBJECT ANTHROPOMETRIC PROFILE**

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**N = 24**

	<b>X</b>	<b>SD</b>	<b>RANGE</b>
Age	20.833	2.220	19.000-28.000
Height	174.585	7.474	162.560-188.600
Weight	69.688	7.105	56.290-84.550
Biceps	4.300	1.333	2.800-7.800
Triceps	8.975	2.281	4.400-14.100
Subscapular	9.742	2.196	5.200-16.400
Suprailiac	10.925	3.881	4.600-19.300
Density	1.067	.007	1.056-1.083
Percent Fat	13.957	2.938	6.870-18.860
Lean Body Mass	59.891	5.758	47.470-73.020

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**TABLE 3.2**

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**SUBJECT AEROBIC EVALUATION**

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**N = 24**

	<b>X</b>	<b>SD</b>	<b>RANGE</b>
Liters/Minute (O <sub>2</sub> STPD)	3.767	.450	3.13-4.87
Milliliters/Minute	54.091	3.783	47.47-60.40
Ventilation (L/min BTPS)	135.300	19.560	97.50-178.10
Max Heart Rate	179.083	38.723	162.00-200.00
Aerobic Threshold (ml·kg <sup>-1</sup> ·min <sup>-1</sup> )	37.913	2.912	32.15-43.67
Percent of Maximum	70.467	5.370	61.00-77.00

**TABLE 3.3**  
**COMPARISON OF MARINE SUBJECTS FROM 2/2 AND 3/5**

	2/2 (N=18)	3/5 (N=24)	(2/2 - 3/5)
	$\bar{X}$	$\bar{X}$	DIFFERENCE
AGE	20.7	20.8	-.1
HEIGHT	179.27	174.58	4.69
TOTAL BODY WEIGHT	73.43	69.69	3.54
PERCENT FAT	15.06	13.96	1.10
LEAN BODY WEIGHT	62.37	59.96	2.41 <sup>+</sup>
FAT WEIGHT	11.01	9.72	1.21
MAXIMUM HEART RATE	194.83	179.08	15.75
MAXIMUM O <sub>2</sub> UPTAKE	3.85	3.77	.08
MAXIMUM O <sub>2</sub> UPTAKE (ML·KG <sup>-1</sup> ·MIN <sup>-1</sup> )	61.72	62.87	-1.15
MAXIMUM O <sub>2</sub> UPTAKE (ML·KG [LEAN] <sup>-1</sup> ·MIN <sup>-1</sup> )	58.48	62.95	-4.46 <sup>++</sup>
ANEROBIC THRESHOLD	33.03	37.91	4.88 <sup>++</sup>

+ p > .01    ++ p > .001

### 3.2 Field Observations Data

Transcribed information obtained from the microcassettes was reduced to narrative form and transferred to a tally sheet by one of the authors (TB). Frequency counts were compared for each of the companies and examined for differences. Essential, critical and frequently performed physical activities are displayed in Tables 3.4 through 3.8. Where appropriate, comments on exposure to environmental factors are noted.

Personal equipment represented the largest load factor imposed upon the marines. A detailed break down of the fighting loads, existence loads and personal clothing are displayed in Tables 3.9 through 3.11. Table 3.12 displays those items which, althoughnot issued, may be required to be worn in a CBR environment.

Estimates of the physical tasks observed, using the data of Passmore and Durin, Goldman, and others, were used to estimate energy costs of these tasks in kcal/min and are displayed in Table 4.1. These data and relevant discussions are contained in the final section of this report. The differences between range and intensity of physical activities observed in this combat environment and those observed under desert conditions are striking. While desert combat may be characterized as predominately motorized/mechanized, with little sustained physical activity, interrupted with bursts of aerobic activity, the high altitude operations evolve around sustained marching at high percentages of one's maximum aerobic capacity.

Figure 3.9 depicts, on a topographical map, the marching routes and bivouac areas covered over the three days of the exercise. On the first day of the exercise, the Super Squad marched from a point midway between "A" and "B", established a defensive position, then skirmished with another platoon and marched, in the dark (with full combat load) back to the



**FIGURE 3.1  
Use of E-Tool**

**Table 3.4**  
**AMBULATION/TROOP MOVEMENT**

	Posture	Frequency	Duration	Chemical Agents	Physical Factors	Geographic Factors	Weight/ Distance	Adm. = A Tactical = T
Walk (V.B. Boots)	Upright	2 - 3 x's per day	Up to 6 hrs.	None	Darkness Deep Snow Rocks, Fallen Trees, Ice	Elevations 8,000' to 9,600' Grade -20° to +40°	Weight 17-50+ Kg 100-8,157 M	T
Walk (Snow Shoes)	Upright	2 - 3 x's per day	Up to 4 hrs.	None	Blaze Trails Rocks, Fallen Trees, Ice Darkness	Elevation 8,500' to 9,600' Grades -15° to +25°	Weight 17-50 Kg Distance 100-5,000M	T
Run (V.B. Boots)	Upright	1 per day	Up to 6 min.	None	Deep, Soft Wet Snow	8,800' to 9,300'	Weight 17.9 Kg Distance 150-200 M	T
Run (Snow Shoes)	Upright	1 per day	6 min.	None	Soft Snow Rocks, Fallen Trees	Downhill 0°-35°	16-30 Kg	T
Pull AIKHIAO	Upright	1 per day	4-40 min.	None	Soft Snow 3-10 Marines Pulling Ice Rocks	± 25°	Up To 2300 lbs	T

**Table 3.5**

**Table 3.6**  
**MANUAL TASKS/UPPER TORSO REQUIREMENTS (NON-TRANSPORT RELATED)**

	Posture	Frequency	Duration	Chemical Agents	Physical Factors	Geographic Factors	Weight/Distance	Adm. = A Tactical = T
d	Upright	1 per day	10-30 min.	None	Ice	Altitude 8,000' to 9,600'	Up to 30 Kg	TA
d								
	Upright Bent Squatting	1 per Exercise	~ 30 min.	None		Altitude 8,000' to 9,000'		A
	Bent	1 per day	30-100 min.	None	Snow	Altitude 8,000' to 9,600'		T
	Upright Bent	1-3 per day	5-15 min.		Ice Snow Fallen Trees Rocks	Altitude 8,000' to 9,600'	1-40 Kg	TA

**Table 3.7**  
**TRANSPORTATION (TRUCKING OR TRACKED VEHICLE)**

Posture	Frequency	Duration	Chemical Agents	Physical Factors	Geographic Factors	Weight/Distance	Adm. = A Tactical = T
Upright	2 x's	10-15 min.	Exhaust Fumes	Ice Snow	7,000' to 8,000'	10 to 30 Kg	
Bentover	2 x's		Exhaust Fumes			10 to 30 Kg	
	2 x's						
Sitting Bentover	2 x's	20-30 min.	Exhaust Fumes	Rough Roads Cold			
	2 x's						
Upright	2 x's	5-10 min	Exhaust Fumes	Ice Snow		10 to 30 Kg	

**Table 3.8**  
**ADMINISTRATIVE TASKS/NON-DYNAMIC**

	Posture	Frequency	Duration	Chemical Agents	Physical Factors	Geographic Factors	Weight/Distance	Adm. = A Tactical = T
Sitting (waiting)	Sitting	2 - 5x day	20 min. to 6 hrs.	Pumes From Stoves In Tents	Cold	8,000' to 9,600'		
Standing (assembly)	Standing	2 - 5x day	8 min. to 87 min.	None	Cold	8,000' to 9,600'	15 to 30 Kg.	
Sleeping	Prone	1 day	3 - 12 hrs	Pumes From Stoves In Tent	Cold	8,000' to 9,600'		
Standing Guard	Upright Sitting	1 to 2 Times Per Day	30 min. to 4 hrs Each Time	None	Cold Wind	8,000' to 9,600'		
Eating/ Cooking	Upright Sitting	3 to 4 Times Per Day	20 min. to 2 hrs	Pumes From Stoves In Tent	Cold	8,000' to 9,600'		



**FIGURE 3.2**  
Detailed View of  
VB Boot and Snow Shoes



**FIGURE 3.3**  
Typical Cold Weather Load



**FIGURE 3.4**  
Transport of Equipment  
and Supplies



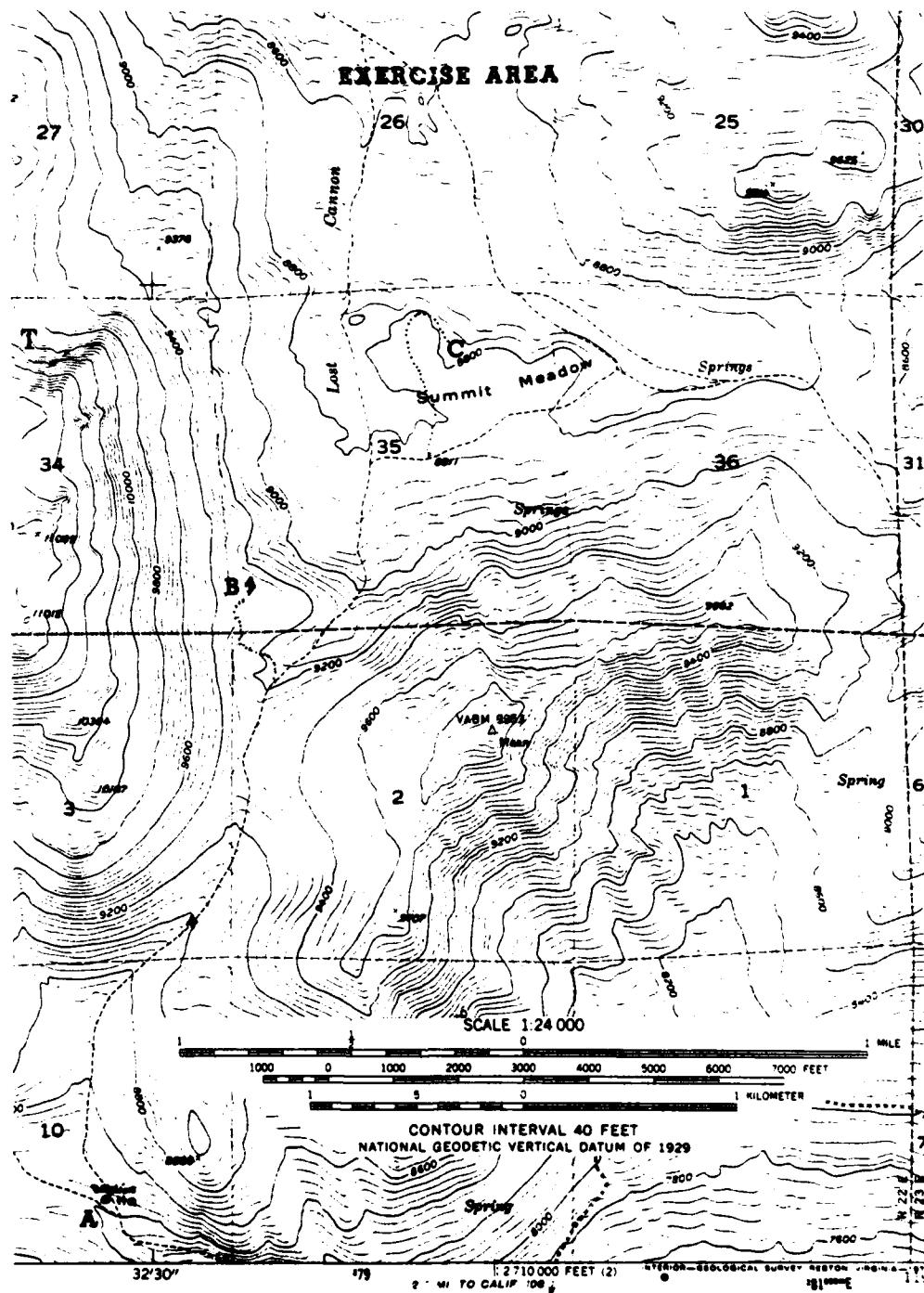
**FIGURE 3.5**  
**Transversing Fresh Fallen Snow**



**FIGURE 3.6**  
**Ten-Man Arctic Tent**  
**A Marine in White**  
**Camouflage Suit**



**FIGURE 3.7**  
**Moving on AK110 Uphill**  
**With Snow Shoes**



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TABLE 3.9

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COLD WEATHER CLOTHING, MEDIUM SIZE

ITEM/DESCRIPTION	QUANTITY	WEIGHT(lbs)
1. long underwear: 50% cotton, 50% wool	1	1.50
2. socks: wool	1	0.19
3. shirt: wool O.G.	1	1.50
4. field trousers: poplin w/ suspenders	1	2.35
5. parka, with liner & hood	1	4.89
6. sunglasses & case	1	0.30
7. cap: pile, w/ velcro flaps	1	0.26
8. boots: vapor barrier, extreme cold (9R)	1	5.50
9. over whites: cotton (camouflage cover)	1	3.20
10. handwarmer, mitts	1	1.10
11. scarf: wool	1	0.38
	TOTAL	21.17

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TABLE 3.10

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COMBAT LOAD, INDIVIDUAL EQUIPMENT

ITEM/DESCRIPTION	QUANTITY	WEIGHT(lbs)
1. H-harness, belts & suspenders	1	3.50
2. canteen, cover & cup, w/water	2	6.00
3. ammo pouch: M-16 3 clip capacity	2	1.46
4. M-16 Clips (5.56mm) w/ammo	5	3.50
5. grenade, M 26	1	1.90
6. first-aid pouch	1	0.80
7. rifle, M-16	1	7.00
8. bayonet, w/scabbard	1	1.07
9. snow shoes, magnesium	1	6.00
	TOTAL	31.23

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TABLE 3.11

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EXISTENCE LOAD

ITEM/DESCRIPTION	QUANTITY	WEIGHT(lbs)
1. entrenching (E) tool w/case	1	2.50
2. ALICE (rucksack) w/frame	1	7.00
3. bag, waterproof	1	0.75
4. sleeping bag: extreme cold	1	9.50
5. mattress: air	1	3.50
6. poncho w/liner	1	1.50
7. toilet articles	1	1.00
8. socks: cushion	2	0.38
9. candles: paraffin	2	0.25
10. rations: combat	7	14.00
11. liner, trousers	1	0.50
12. matches: box	1	0.15
13. face mask: arctic	1	0.25
TOTAL		40.61

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TABLE 3.12

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PERSONAL PROTECTION EQUIPMENT  
(Not issued or worn on operation)

ITEM/DESCRIPTION	QUANTITY	WEIGHT(lbs)
1. helmet w/liner	1	3.85
2. body armor	1	11.68
3. suit: chemical protective	1	4.00
4. glove set: chemical protective	1	0.50
5. footwear cover: chemical protective	1	1.80
6. mask: field protective w/case	1	3.94
TOTAL		25.77

battalion headquarters at point A. While more than six hours were spent marching, less than four miles was covered.

On the last day of the exercise, the squad marched from point C, pulling an AHIND for a portion of the way, back to point A. From A to the main base is another 4 miles. The road conditions below the base camp were considerably more favorable for walking than were conditions at higher elevations.

## SECTION 4.0: DISCUSSION

The purpose of this investigation was to gather information regarding the physical performance tasks required of U.S. Marines operating in a high altitude/cold weather (HA/CW) combat environment. Data from ten separate observers were compiled according to the most critical and frequent physical tasks observed under these conditions. Several dimensions or components of physical fitness were identified as essential to the effective completion of a number of combat tasks. Specifically, a high absolute and relative aerobic work capacity has been identified as a necessary requirement. (Absolute work refers to energy being expended to move objects external to the body, while relative work refers to movement of one's own body.) Additionally, relative and absolute muscular endurance is a requirement for a significant number of the movement tasks that are performed while wearing load-bearing equipment (i.e. pack and 782 gear). The specific nature of the physical tasks will be discussed under the appropriate headings. Table 4.1 lists these critical and frequent physical tasks and provides estimates of the oxygen uptake costs associated with performance of the task. These estimates have been derived from the published references noted on the right side of the table. A straightforward requirement for high levels of physical work capacity are typical of all aspects of this combat environment.

### 4.1 Critical Tasks

For the purpose of this work, a critical task is one defined as extremely important to the successful completion of a job. An inability to complete such a task could conceivably result in loss or destruction of property, injury to self or co-workers, or loss of life. In essence, a

critical task is important to successful fulfillment of the MOS 0311 function. Due to the nature of the terrain, movement via foot or on snow shoes was judged as vital to the success of the mission in this environment. The ability to march, encumbered with heavy, restrictive clothing and equipment totaling at times more than 70% of one's body weight through new fallen snow on snow shoes was judged as the most critical task observed under these conditions. Figure 4.1, employing the predictive model of Givoni and Goldman<sup>(13)</sup> attempts to demonstrate the energy costs associated with movement in this terrain.

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FIGURE 4.1

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MATHEMATICAL MODEL FOR DETERMINING ENERGY COST OF HUMAN MOVEMENT

$$M = n(W + L)[2.3 + 0.32(V - 2.5)^{1.05} + G(.2 + 0.07(V - 2.5))]$$

where:

M = metabolic rate, kcal/hr

n = terrain factor, defined as 1 for level treadmill walking

W = body weight, kg (Average: 69.68)

L = external load, kg (Pack wt: 26.12kg; Clothing: 9.98kg)

V = walking speed, km/hr (On level terrain - 4km/hr)

G = slope (grade), % (Average grade: 8%)

Extrapolation for HA/CW conditions: 588.7 kcal/hr (9.8/min) on a level grade. Maintenance of this rate on an incline of 8° would represent an hourly metabolic rate of 1053 kcal, or 17.5 kcal/min

The hourly metabolic rate is uncorrected for load site. External load represents 51.8% of body weight. The terrain factor estimated to be 1.8 (minimum).

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#### **4.2 Frequently Performed Tasks**

The next category of tasks were found to be necessary for the effective completion of support and reserve activities. While high energy requirements are not always associated with these tasks, they are nevertheless important to the overall mission of the marines in a cold weather environment. Lacking the critical nature of personal mobility and transport, these tasks are, nonetheless, necessary to the successful completion of the mission. These tasks are described below.

##### **4.2.1 Lift and Carry**

In most modern combat theaters, where mechanized transport abounds, the cold weather mountain environment stands out as a notable exception, requiring high levels of physical conditioning. Since motorized transportation is incapable of surmounting the obstacles encountered under these conditions, the individual marine is still required to manually handle supplies and equipment. The hobbling effects of the clothing and standing in deep, powdered snow add to the difficulties associated with material handling.

Typical of each day's operation is the carrying of one's personal equipment and supplies. The usual method for transport of this equipment for short distances (300 feet) is to carry the object on the shoulder or cradled in the arms. For longer distances, these items are carried in the ALICE pack. Generally, the loads do not approach the maximum lifting capacity of the individual marine. However, considerable additional effort is required to ambulate over the snow and to maintain balance. C rations, water and wood were the most frequently observed items carried. The water can, with insulated cover, contains 5 gallons and weighs 45 pounds. The Marine company is the end-user in the supply chain, so all of the necessary support materials are off-loaded and distributed through human effort.

Heavy objects that can not be carried by hand are towed in an AHIKO. Typically, this aluminum sled will be loaded with a 10 man tent, large scoop shovel, yukon stove, gasoline and other assorted equipment. The total weight can approach 350 pounds when the sled is fully loaded. The runners of the AHIKO are not waxed, making the dragging/pulling effort difficult. Four or more marines may be required to move the AHIKO, and as many as 10 marines may be required to move the sled up steep grades. In one episode, 10 marines took 45 minutes to move the sled up a 100 yard grade of 15°. Since little motorized transport was used in this operation, pushing stuck vehicles was observed infrequently.

#### 4.2.3 Digging/Use of Hand tools

The E (entrenching) tool was used for constructing sleeping shelters in the snow and for the construction of defensive positions. The short handle, although mechanically inefficient, is required because of weight and space restrictions. Whenever possible, marines would use the large scoop shovel. (However, marines operating as aggressors did not have this ancillary equipment -- i.e. scoop shovels.) While the physical costs of digging with more traditional methods of excavation have been determined (14), no effective comparisons with the E tool can be made because of several major differences in the present conditions. First, the short shaft on the shovel required that digging be conducted while squatting. Secondly, if the marine was receiving fire, the rate of digging was significantly accelerated. Thirdly, the consistency of snow changes drastically with weather and temperature changes.

#### **4.2.4 Walking/Marching**

All movement in this environment is accomplished on foot. Snow shoes and skis greatly enhance movement over this terrain, particularly when new fallen snow exceeds more than 8 inches. Therefore, estimation techniques employed for rates of travel by troops on firm ground under more conventional conditions require significant alteration. Four major factors impact upon the capability for sustained walking. These factors include the hobbling effects of heavy clothing, the weight of the foot wear and snow shoes, the heavy loads carried, the steep inclinations encountered and altitude. The physiological burden imposed on the marines operating in this environment represents a 50% to 75% diminution of capabilities compared to more temperate environments. It appears to take twice as long to cover half the distance that one might cover in temperate, low altitude conditions. Maximum oxygen consumption values for this altitude are diminished by a factor of 15% for acute exposures, while among acclimatized personnel, these values are reduced by 5% to 10% (15,16). Reconstruction of coordinates and rendezvous sites were used for the development of rates of travel data contained in Tables 3.4-3.8. These rates of travel were much slower than expected by the marines or their commanders.

Many investigators have determined the energy costs of sustained hiking/marching under a number of conditions including energy expenditure under polar conditions. Using the model of Givoni and Goldman (13), predictions of energy expenditure in this environment parallel those measured by other investigators. (Table 4.2 contains a summary of these findings.) Using a terrain factor of 1.8t, (where t=1 for the value assigned to walking on a motor-driven treadmill), estimations were made for movement under the present conditions. Based on an extrapolation from this predictive formula, it was the consensus of the observation team

members that an 11 MET requirement is imposed on the marines while walking under these conditions. This explains the frequent requirement (every 15 minutes) for rest stops.

#### 4.3 Environmental Overlays

The high altitude, snow-covered environment is unique in the demands imposed on marines. Failure to recognize and consider the implications of this environment can drastically distort operational requirements. It is difficult to convey all the encumbrances associated with maintenance of basal tasks in this environment. Every physical task is confounded by heavy and awkward equipment. Tasks which are considered routine, such as securing straps and rolling up sleeping bags, become major events because of the extreme cold and restrictions imposed by heavy clothing. Even members of the observation team who were in excellent physical condition and who normally encounter little difficulty in documenting and recording data using the devices described earlier, found it a major effort to do more than continue in the line of march and maintain contact with their subjects under these conditions. Attempts in taking other measurements such as temperature and inclination were confounded by trying to free the necessary equipment from difficult-to-reach pockets while wearing clumsy gloves. Because the marines can be exposed to periods of intense activity while wearing heavy clothing, they experienced profuse sweating which, when followed by periods of rest, results in rapid cooling due to evaporative heat loss. The resulting effect is one of extreme discomfort.

#### **4.4 Water**

Water can represent a logistical weapon in this climate. While snow abounds, melting it for water is very inefficient in terms of physiological energy costs. Because of the low relative humidity, and the rapid evaporation of perspiration, and loss of fluids in expired air, dehydration can quickly become a rapid physiologic state. Significant impairment can, therefore, result without an adequate water replacement schedule. Perception of thirst is also significantly curtailed, necessitating in a concentrated effort on the part of NCO's and officers to force hydration. In man the loss of 2 quarts of body water results in a 25% reduction in physiological efficiency (17). Such a loss under these conditions while marching would be nominally expected within one (1) hour.

#### **4.5 Deriving Physical Fitness Standards**

A considerable amount of data are available on the relationships between energy costs and the carrying or wearing equipment (18-24). These data suggest that pace will adjust to the load being carried. While estimates of energy costs associated with many marine corps tasks performed under desert conditions could be inferred from similar work performed by civilian occupational specialties exposed to hot, arid conditions, such data do not exist for work performed in cold environments. It is recommended that a standardized set of physical tasks derived from those identified above be established and that energy costs be assessed under conditions that simulate those documented during these HA/CW operations.

Energy costs can be assessed under field conditions as suggested by Liddell (25), Consolazio (26), Verma and others (27) through the use of portable metabolic measurement equipment. However, the face validity of this approach is mitigated by the problems associated with working under

these onerous conditions. As a substitute procedure, simulation of these scenarios in the laboratory can be accomplished in the following manner: an environmental chamber can be used to accurately replicate the temperatures, altitudes and humidity variables encountered in the HA/CW environment. A treadmill will allow for programming and reproduction of grades and speeds required during the critical tasks. Using the observed tasks as the criterion of performance, a standardized set of reproducible, laboratory-based tasks can be conducted during which metabolic measurements would be assessed. Contingency planning for combat preparedness should always include the worst case condition as the criterion of performance effectiveness. Due to the nature of the combat environment and the time constraints imposed on the completion of these tasks, a number of specific tasks should be performed in a sequential manner in order to fully tax the subject's oxygen delivery system.

A battery of simple and complex physical fitness tests would also be administered to the same subject group during a later testing period. The criteria for inclusion of an item in the battery of predictors should be as follows: (1) be a "pure" (one dimension) predictor; (2) have a high degree of test-retest reliability; and (3) lend itself for use as an expedient, easily-administrated performance test.

Multiple regression analysis of the relationships between the battery of predictors and the criterion tasks would insure that the Marine Corps had a truly useful, job-related physical performance test that would accurately predict combat readiness for a HA/CW environment. This methodology would give the appropriate weightings for each of the dimensions of fitness in accordance with the order of their importance in predicting performance on the criterion tasks. It would also allow for rationale establishment of minimum levels or cut-off, identifying those

#### **DISCUSSION 39**

individuals whose physical abilities, could compromise the successful completion of a combat operation.

No doubt, the best approach to the development and validation of a comprehensive job-related test battery is to ensure that data from all theaters of operation are assessed and included in the taxonomy of job tasks. This will be accomplished in future work under this program.

TABLE 4.1

## SUMMARY OF OBSERVED PHYSICAL TASKS WITH REFERENCE TO ENERGY COSTS\*

CATEGORY/TASK	KCAL·MIN <sup>-1</sup>	CITATION
Sitting in vehicle	1.7	14
Standing (no load)	1.51	14
Standing, loaded		
10kg	1.56	23
20kg	1.78	23
30kg	2.07	23
<u>WALKING:</u>		
slow (no load) 5.5 Km/hr smooth surface (91.6 m/m)	5.6	14,23 13
rough surface " "	7.6	13
sandy surface, (50 lbs)	9.87	28
loaded, up grade (40 Kg, +10%)	9.91	24
loaded, down grade (40 kg, -10%)	4.66	21
mechanical energy aspects of running and walking		29,30,31
<u>RUNNING</u> (5-7 mph)	1.5 kcal/kg/mile	14,32,33
low crawl	9.1	14
impact of body weight on energy cost	0.047(w) + 1.024	34
Implications for sustained performance		35,36,37
digging	5.4	14
lifting/loading	4.5-10.0	38,39 40,41

\* Assuming 150 lb. individual for most values

TABLE 4.2

## ENERGY COSTS OF COLD WEATHER RELATED ACTIVITIES\*

ACTIVITY	ENVIRONMENT	METHOD OF MEASUREMENT	ENERGY COST	REF
SLEDGING MAN AND DOG	STEP AREAS	WRIGHT RESPIROMETER	6,500 KCAL/DAY	42
PULLING SLED	UPHILL	WRIGHT RESPIROMETER	15.2 KCAL/MIN	42
2 MAN SLED	2 MPH; 9-12MI PER DAY; 110KG LOAD	DOUGLAS BAGS	230 KCAL/MILE 3.3 KCAL/KG BODY WT/MI	43
3 MAN SLED	158 KG LOAD + PACK & WEAPON 1.3 MPH	K-M RESPIROMETER	8.6-10.4 KCAL/ MIN DEPEND. ON POSITION 4.8 FOR BACKPACK ONLY	44
FOOT/LEVEL ON TRAIL	2.3 MPH	WOLF INTEGRATING MOTOR PNEUMOTACH	5 KCAL/MIN	45
FOOT/LEVEL DEEP SNOW	2.3 MPH	" " "	11.9 KCAL/MIN	45
SNOWSHOES	DEEP SNOW	" " "	"GREATER THAN WALKING IN DEEP SNOW"	46
SNOWSHOES	2ND MAN	" " "	70% LESS THAN WALKING IN DEEP SNOW	
SNOWSHOES	5TH MAN	" " "	50% LESS THAN WALKING IN DEEP SNOW	
SKIING	3 MPH IN TRAIL	" " "	7.4 KCAL/MIN (ABOVE RESTING)	
SKIING	6.1 MPH	" " "	14.6 KCAL/MIN (ABOVE RESTING)	

\*Source: O'Hara (46)

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## SECTION 6.0 APPENDIX

This Appendix, the basis for the article entitled: Let's Not Leave the Marines out in the Cold, (U.S. Naval Institute Proceedings November, 1981) examines logistical factors that affect sustained combat performance under high altitude, cold weather conditions. Equipment, hygiene, life support (food/messing and water), transportation, communications and medical care will be discussed as they affected the sustained performance of the marine combat infantryman.

### 6.1 The Environment

The Mountain Warfare Training Center (MWTC) is located in the Sierra Mountain, on the Toiyabe National Forest in Northern California. The base camp is 6,700 feet above sea level, overlooking Pickel Meadows and Highway 108. It is an excellent location for high altitude, cold weather infantry training. Field exercises are conducted at altitudes of 7,000 - 10,000 feet, with temperatures typically ranging from -20°F to 50°. Snow accumulation ranges between 3 and 15 feet. The MWTC is a cold, dry environment much like the Arctic, but with high altitudes. The MWTC has a variable terrain, including expanses of open glade, bounded by sheer cliffs.

Measurements of these marines by the Naval Health Research Laboratory at San Diego before their exposure to cold weather conditions at MWTC demonstrated that they were physically fit. Their field performance under the extreme conditions at MWTC was judged to be of exceptional. But it was apparent that these troops carried loads that were detrimental to their extended and efficient performance in a high altitude, cold weather, environment.

## 6.2 Personal Equipment

No single factor had more influence on the individual marine's mobility than the equipment he wore or carried. The equipment that was issued, listed in Tables 3.9 through 3.11. Each piece of equipment was weighed in the field with spring scales. Additional information was provided by the U.S. Army Clothing and Equipment Materials Engineering Laboratory (CAMEL) in Natick, Massachusetts, and the Mobility and Logistics Division Development Center, Marine Corps Development and Education Command (MCDEC) in Quantico, Virginia.

Table 3.9 describes the cold weather clothing worn during this typical, six-day cold weather exercise. Table 3.10 contains the combat load that is generally worn or carried by each marine during tactical exercises. Equipment listed in Table 3.11 was essential to cold weather survival (existence gear). It was clear that if any of the equipment described in Table 3.11 was lost, arctic survival would be difficult if not impossible.

In addition to the clothing, combat and existence loads, a marine may be required to carry a battery for the PRC-77 radio (2.85 pounds), or the radio itself (26.90 pounds). Other items routinely carried were mortar base plates, machine guns, tripods, and 5-gallon cans of water.

The troops were poor judges of the amount of weight they carried. When asked to guess the weight of their packs, estimates were off as much as 33 percent. The troops were also uncertain about what equipment was to be carried into the field and what was to be left behind at base camp.

As seen in Table 3.9, the marine adds 21.17 pounds to his frame by donning the cold-weather clothing. The fighting load brings his total to 54.2 pounds, of which 12 pounds are worn on the feet. The existence load, with pack and contents as shown in Table 3.11, puts the total at 93 pounds

for a medium-size clothing issue, with considerable ranges of weight actually carried in the pack (25 pounds for the lightest pack observed to 81 pounds for a radio operator). But the marine with the 25-pound pack was found to have many essential items missing and suffered accordingly.

This equipment greatly reduces mobility, decreases tactile and sensory perception, and interferes with the body's vital cooling process during increased exertion (which is common in mountainous terrain). Walking on snowshoes with a 100-pound burden is an enormous physical task. During a hike, metabolic rate over basal state is increased by a factor of 15 over that of resting. While we did not have the capability to perform direct measurements, we were able to infer the true physical cost of work under these circumstances. In a previous project, during which we determined the energy costs to firefighters of wearing protective equipment, it was found that 52 pounds of protective equipment reduced efficiency by 33%. In as much as the firefighters in this project were physically larger than the marines, we can infer that the items contained in Tables 3.9 and 3.10 reduce effectiveness in any sustained type of physical activity, particularly in individuals with body weights less than 170 pounds, by 33%.

### **6.3 Clothing**

For the most part, the cold weather clothing issued to the troops will keep them warm. However, this clothing can cause heat exhaustion because it is not properly ventilated. Bulk and layering are necessary to conserve body heat, but this can also be achieved with lightweight, long-wearing garments that are available commercially. These alternative garments are warm and conserve body heat by transferring the evaporative surface from the skin to the outer layer of the garment.

Each marine was issued a cold weather cap, a wool shirt, field trousers, and a parka. The cold weather cap lacks a visor which could serve the marine in bright sunlight or heavy snowfall. The wool shirt, while durable and exceedingly warm, readily absorbs moisture in a heavy snow or rain, thereby increasing the risk of hypothermia. The field trousers are very durable but bulky and absorbent. When the trousers get wet, they are very uncomfortable. The parka provides little protection from rain or melting snow because it is not water-repellent. When removed, the parka is difficult to store because it cannot be compressed. Several marines told us they preferred to wear their camouflage utilities because they dried more quickly than their cold weather gear. But utilities offered little protection from the cold.

No single piece of personal equipment is as important as footwear. The "Mickey Mouse" boot (so called because of its similarity to the cartoon character's feet) is an impressive piece of equipment being both warm and lightweight. It comes in two versions: white for extreme temperatures (to 60°F) and a black (to -10°F). The boot travels well in packed snow. However, on long hikes over sloped, bare ground, it can cause serious blistering. In addition, moisture is a constant problem with this vapor barrier boot. The marine must frequently change socks, powder and perform other time-consuming maintenance (which is seldom done) to prevent immersion foot, athletes foot, and foot odor.

The balance of the personal protective wearing apparel is too heavy and bulky for practical use under cold weather combat conditions. Most of the marines discarded their web gear (M-16 clip pouches, canteens and covers) because of the difficulty in using these items with the ALICE pack

or their heavy loads. Other marines stuffed these items into their pockets. Many variations in equipment must be made in view of individual size structure.

#### 6.4 Pack

While the pack is reasonably well-suited for loads up to 35 pounds, it taxes the trapezius muscle groups when overloaded as it was under these conditions. It is not possible to adjust an overloaded pack to relieve this strain. The outside pouches give easy access to frequently needed items, but picking up and putting on the pack, especially while on snowshoes, requires considerable effort. The main straps for closing the cover are difficult to fasten with cold hands in sub-freezing weather.

Attaching a sleeping bag or other object that will not fit readily in the pack is next to impossible because the straps are too short to fit easily over the extra bulk. We observed a host of methods for attaching sleeping bags to the pack (underslinging it beneath the pack, placing it under the top flaps, or making it into a horseshoe roll). A sleeping bag or any optional equipment should always be carried high on the back. Lowering the weight not only makes the pack more awkward to carry, but significantly increases the likelihood of disabling injury. Four marines from one squad sustained muscle injuries resulting from weight-bearing activities like this. There was no way to rest the back muscles except to drop the pack (with the prospect of having to pick it up again), or to sit down in wet snow. The sleeping bag is durable, but bulky and heavy (weighing 9.5 pounds). The ideal bag weight is under 6 pounds, and many models are commercially available in fast-drying materials. Lightweight foam pads should also be considered as an alternative to the 3.5-pound air mattress currently used.

#### **6.5 Shelter**

Expedient shelters are essential, even under these simulated combat field conditions. The marines respond well to the job of constructing "hootches", but just as a new lodging was completed, orders were given to "move out", resulting in loss of time and energy. Sheltering in snow caves, and other types of expedient lodging, are preferable to the 10-man arctic tent. The 10-man arctic tent is a comfortable lodging, but difficult to move or to rapidly disassemble. Therefore, its use is limited to semi-permanent conditions. The tent, weighing 73 pounds, is usually moved by vehicle, but may have to be towed on an AHIKO (problems with AHIKOS are described below).

The arctic tent was also a health hazard. With a Yukon stove, the interior temperature becomes a toasty 70°F. Coupled with exhaled air, the 15 to 23 marines stuffed into this 10-man tent are at increased risk for upper respiratory infections, as evidenced by persistent coughs among at least half the members of the Battalion. Reducing the temperature difference between the inside and outside environment would be an effective way to reduce discomfort and coughing, as well as to improve adaptation to cold weather. We found that the heater/stove was unnecessary for warmth. Close supervision by NCOs and officers could eliminate over-heating, and its adverse effects.

#### **6.6 Messing**

The Yukon stove, even with wood fuel, provides an acceptable cooking surface. The smaller squad stove was useless because of the excessive maintenance problems associated with it. Heat tabs (a fuel source consisting of trioxane) were found to burn slowly, but effectively. Obviously, heat must be provided since C-rations are next to impossible to

eat frozen. On opening, the ring of fat sprinkled with metal filings caused by the can opener, was found to reduce the appetite substantially. (It should be remembered that at least 4500 calories per day are required under these conditions, so a healthy appetite is essential to maintaining proper energy levels). As an alternative to C-rations, some members of the observation team carried LRPS (long range patrol rations), a freeze-dried meal that can be eaten dry or cooked by adding water. Although the LRPS were time-consuming to prepare, they were nevertheless a significant improvement over C-rations. Needless to say, the marines were envious of this compact, lightweight ration. A single C-ration meal weighs 2 pounds, while the LRPS weighs only 4 ounces. This is a staggering difference if you consider that 7 meals (the required number) added 14 pounds to the total load, while LRPS meals added less than 2 pounds. (The meals-ready to eat (MRE) being developed by the Army will help reduce this load to about two pounds for seven meals.)

Cold weather dehydration was a serious and common problem. Dehydration under these conditions is caused by a combination of low humidity, altitude, and exercise. Dehydration produces a host of complications including exhaustion, increased susceptibility to frostbite and, if wounded, shock. Freeze-dried food presents an excellent mechanism for ensuring that the individual remains hydrated, provided that water is available for reconstituting the food.

Using a half quart of water to prepare the meal and a half quart for a warm drink, each marine would consume approximately three quarts of water a day with meals. (This assumes that time exists for these meals in combat). During the exercise which we observed, there was one 18-hour period in which messing was not possible. The disproportionate high quantity of protein in the (C-ration) and MRE is a questionable feature because

carbohydrates are the critical food fuels needed for extended physical activity. The traditional quick-energy consumables, (e.g. chocolate and caffeine beverages) compound the problem of dehydration by increasing the excretion of body water (as urine), yet the items are provided in copious quantities in C-rations and MRE's. So, if these carbohydrates items are consumed, additional water must be consumed.

The likelihood of being able to drink sufficient water from a plastic canteen at 32°F or below is remote because the canteen, though lightweight and cheap, allows water to quickly freeze and thawing is a major problem (because of the plastic material). This is another equipment problem that contributes to dehydration. A conscious effort must be made to maintain hydration through forced drinking and observation of urine color (urine turns dark during dehydration). Indeed, water supply in a combat environment represents a major logistical problem. Melting snow is extremely inefficient. We understand that water supply problems are currently being investigated because water has to be considered a tactical weapon.

Effective sanitation associated with the clean-up of messng gear was not possible, because of water shortages. The LRPS require no clean-up, thoroughly eliminating this problem - another advantage for using LRPS.

#### 6.7 Movement

Snowshoes or skis are the only realistic method of movement in deep snow. Moving through snow is fatiguing under any mode. Trail blazers need to be frequently rotated. Snowshoes are the primary equipment for walking in deep, unpacked snow. The regular issue snowshoe is simple in design and function. The ease of fastening is an advantage, especially when it is necessary to keep exposure of bare fingers to a minimum. The metal frame

and wire-mesh appear durable. Some reduction in weight would no doubt ease the marine's burden. Adjusting to walking with snowshoes is accomplished in a few hours, but accommodation to skis takes significantly longer. The marine's 207cm skis had no safety releases and were less than optimum for efficient movement; without wax, movement uphill in skis was virtually impossible. Our ski group had to follow us (we were using snowshoes), and the ski squad was hard pressed to keep up.

Our observation team's experience on cross-country skis leads us to believe that the whole concept of using skis for marine operations should be reevaluated in view of the availability of short, lightweight, cross-country skis. However, even individuals with cross-country skiing experience require annual training.

Transporting arctic tents and supplies for short distances is accomplished via the ANIKO. This is a sled on waxless skis towed by two or three marines in harnesses and one marine following in trace. The typical load carried on the ANIKO is 350 pounds. Uphill movement changes the manpower requirements dramatically. A 10-man team took 45 minutes to move an ANIKO only 200 meters up an 18 degree grade.

Mechanized support in this exercise was poor to nonexistent. Trucks with chains are only effective on packed surfaces with grades of less than 6 degrees. Tracked vehicles designed primarily for warm weather amphibious operations do not perform satisfactorily in snow. While there are tracked vehicles for snow and the cold, we had none at MWTC. Helicopters were unavailable because of other operational commitments. In any event, helicopters are unreliable because poor weather can quickly preclude deployment.

Snowmobiles, on evaluation from MCDEC at Quantico, show promise for high-speed transport of reconnaissance and strike groups. While underpowered for heavy hauling operations, snowmobiles have excellent promise if a sturdy "military" version were to be developed with an adequate power-to-weight ratio. However, the snowmobile's engine is unreliable at extreme temperatures.

#### **6.8 Communications**

The old PRC-25 radio has been replaced by the new long-range PRC-77, but the weight (22 to 26 pounds) remains the same. The marines claim that the PRC-77 is reliable but electronically outdated. We were unable to effectively communicate with the Command Post for more than two days—an unusual occurrence, we were told. Nevertheless, use of modern electronics would lessen this weight considerably, as well as improve reliability.

#### **6.9 Medical Support**

The corpsmen are critical to the effective combat readiness of all marine units. We were most impressed with the work of the corpsmen in preventing and caring for cold weather injuries. Their constant attention to the medical needs of the unit was most reassuring. Corpsmen carried the weapons and packs of injured or sick marines without a complaint. But a single marine casualty causes the "loss" of at least four additional marines who are required to tow him on an AHICO. The long-term prognosis for a severely injured soldier is bleak under these cold weather conditions.

#### **6.10 SUMMARY**

Strategically, we are sapping the fighting force of the Marine Corps by using standard issue life-support equipment that takes more from the man than it gives to him in return. Antiquated supplies and equipment are undermining chances for success of Marine Corps cold weather operations. Ignoring the physiological stresses of coping with outdated, inadequate and overweight gear could prove to be crippling, if not fatal, in actual combat conditions.

If marines are to fight in the cold, then technology should be brought to bear in this common sense area of logistics.



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